Occurrence of Radium Isotopes in the Cambrian-Ordovician Aquifer System

U.S. Geological Survey
National Water Quality Assessment Project

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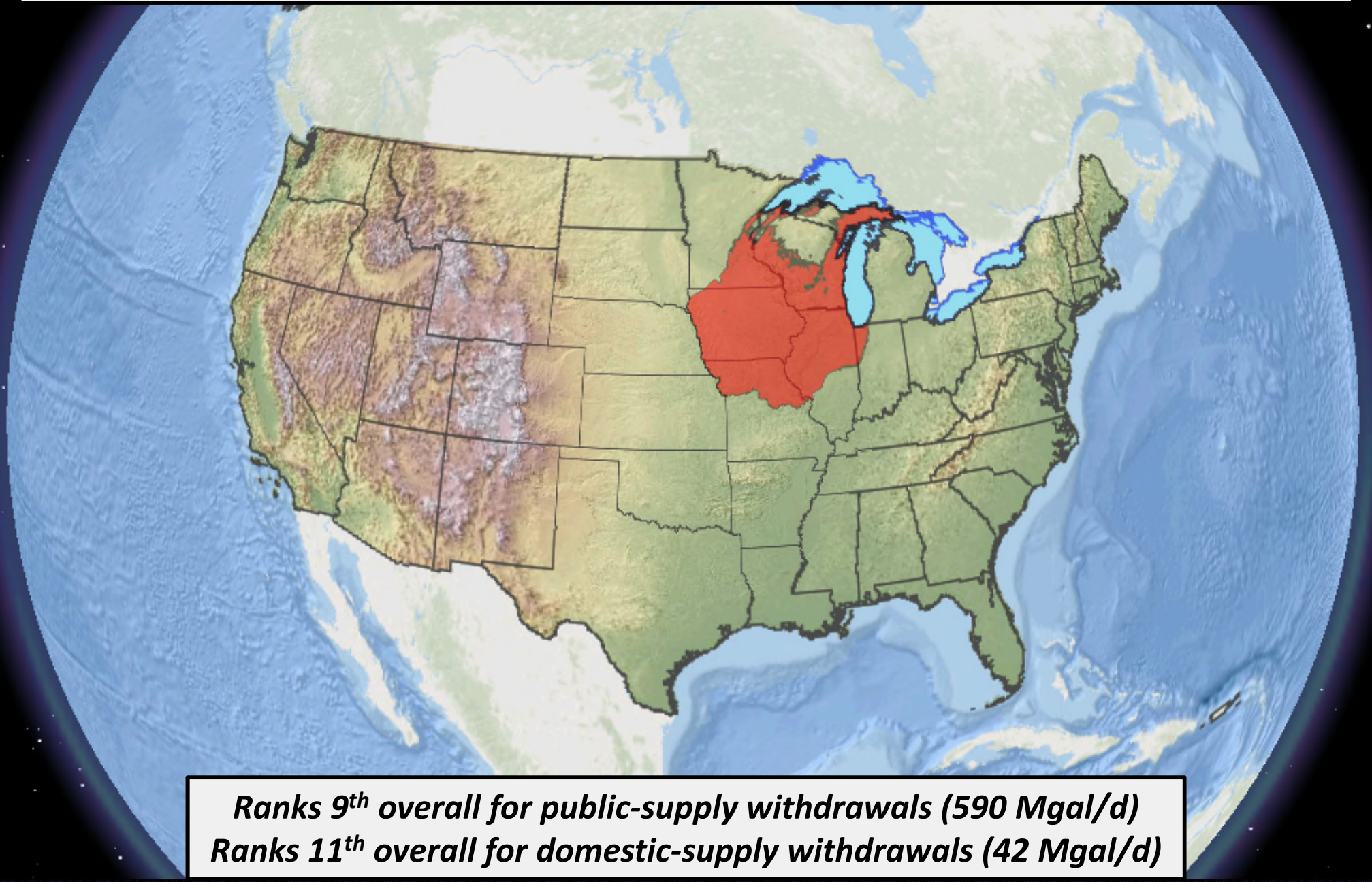
USGS

U.S. Department of the Interior
U.S. Geological Survey

Cambrian-Ordovician Aquifer System



Ranks 9th overall for public-supply withdrawals (590 Mgal/d)
Ranks 11th overall for domestic-supply withdrawals (42 Mgal/d)

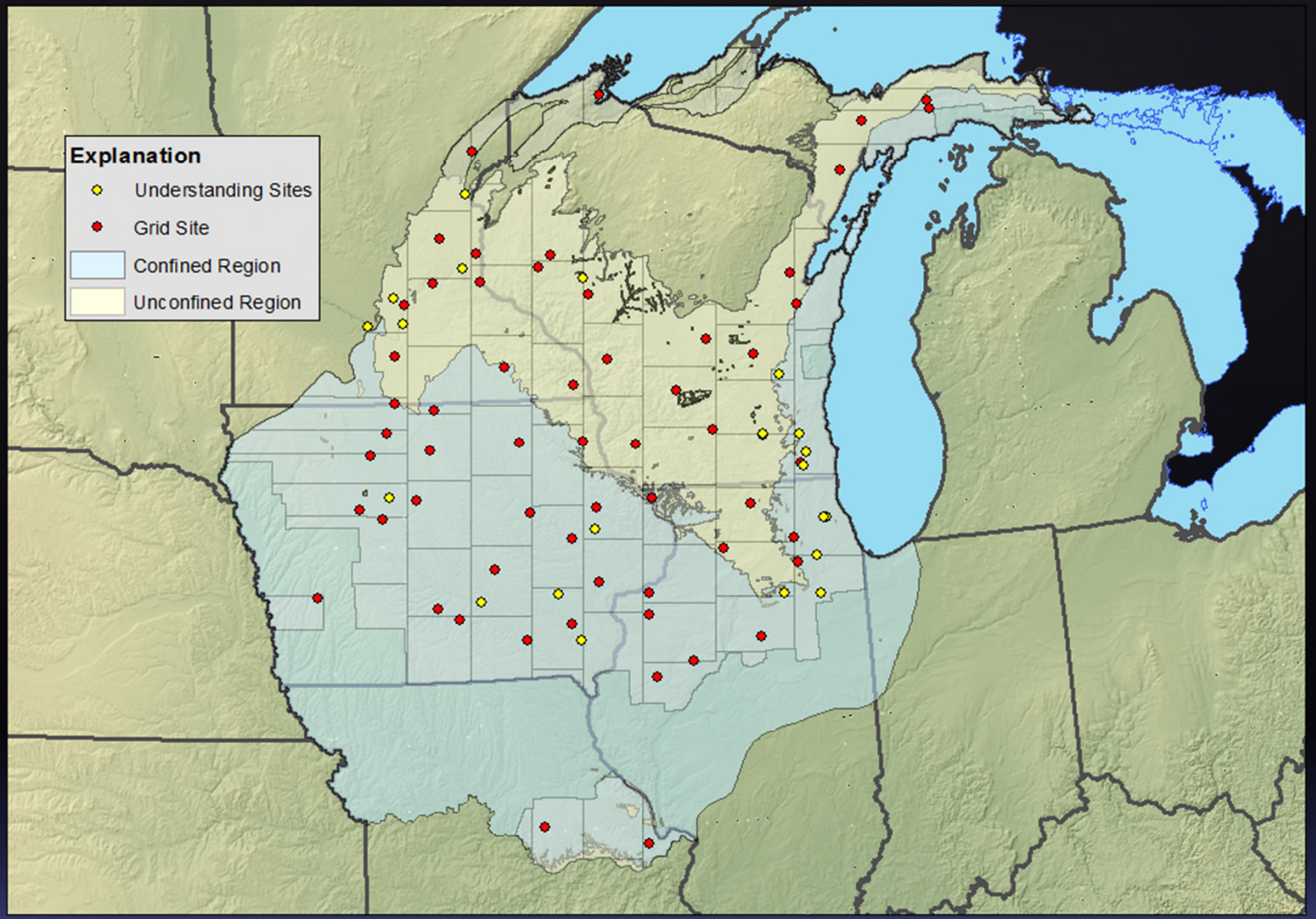
USGS

Confinement & Flow Paths

from J. Wilson, USGS SIR 2011-5229

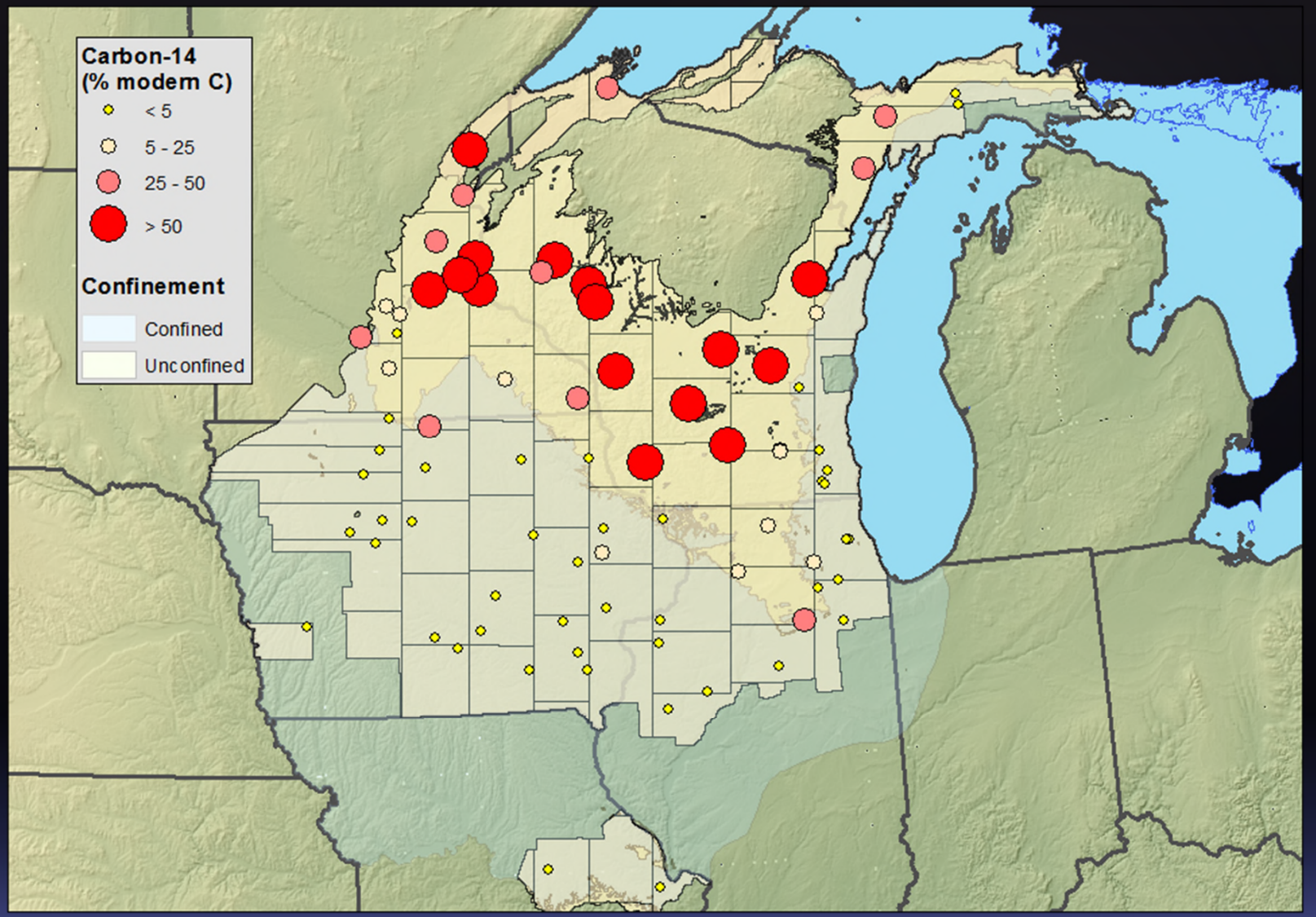
USGS

Well Locations



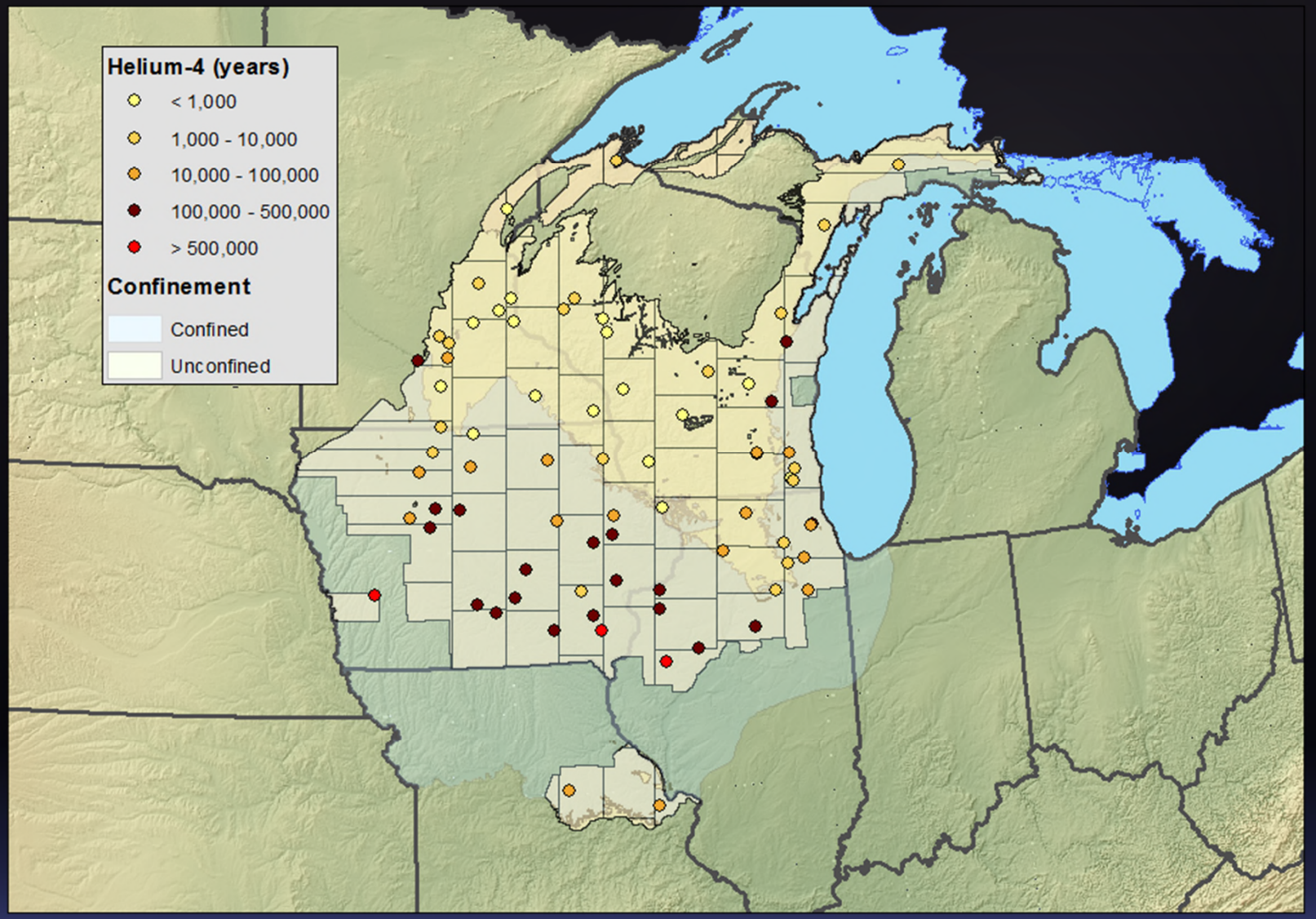
USGS

Carbon-14



USGS

Helium-4



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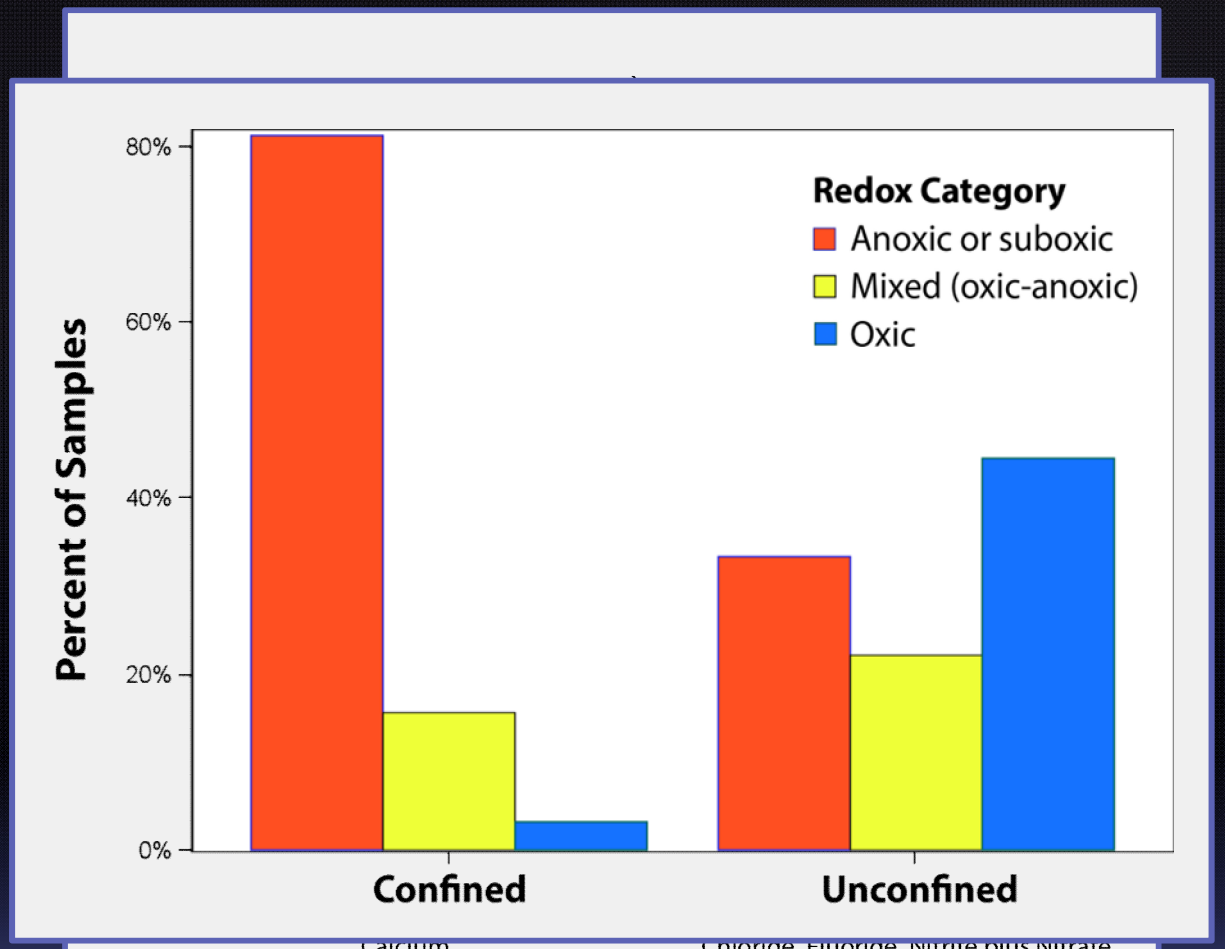
Water Type & Redox Condition Evolves with Age



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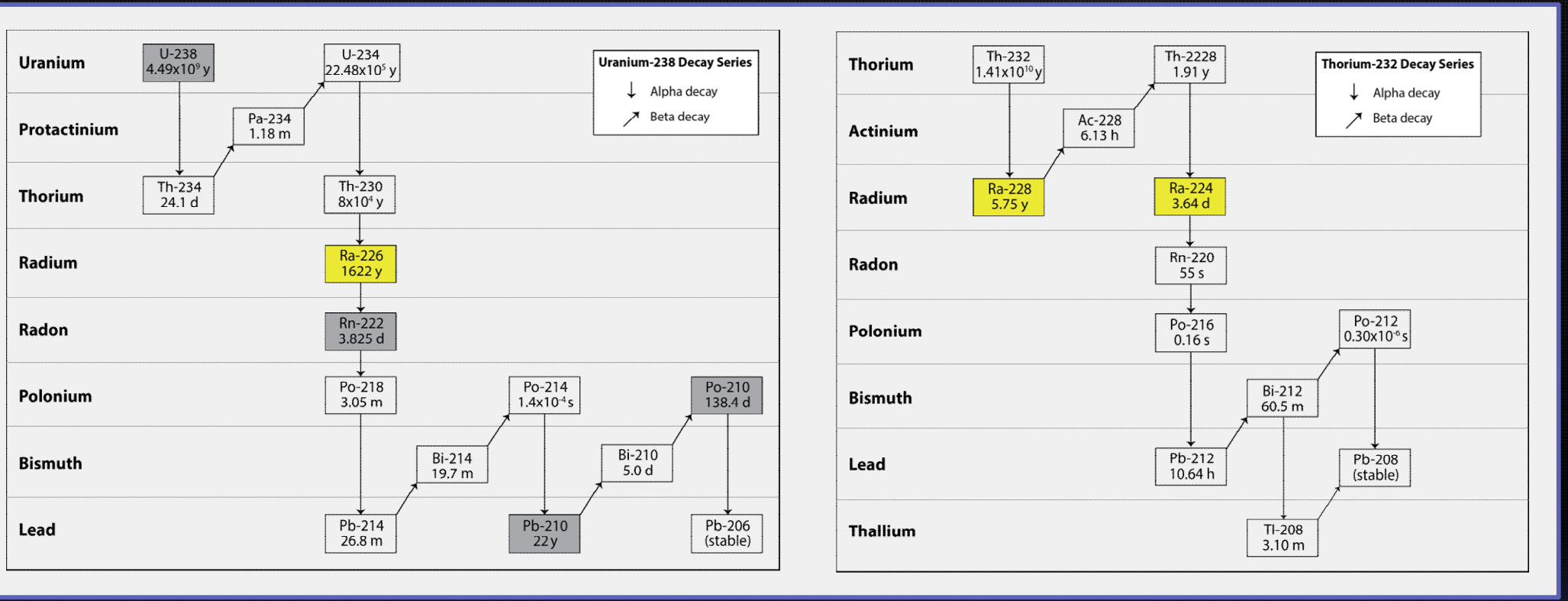
^{238}U and ^{232}Th Decay Series

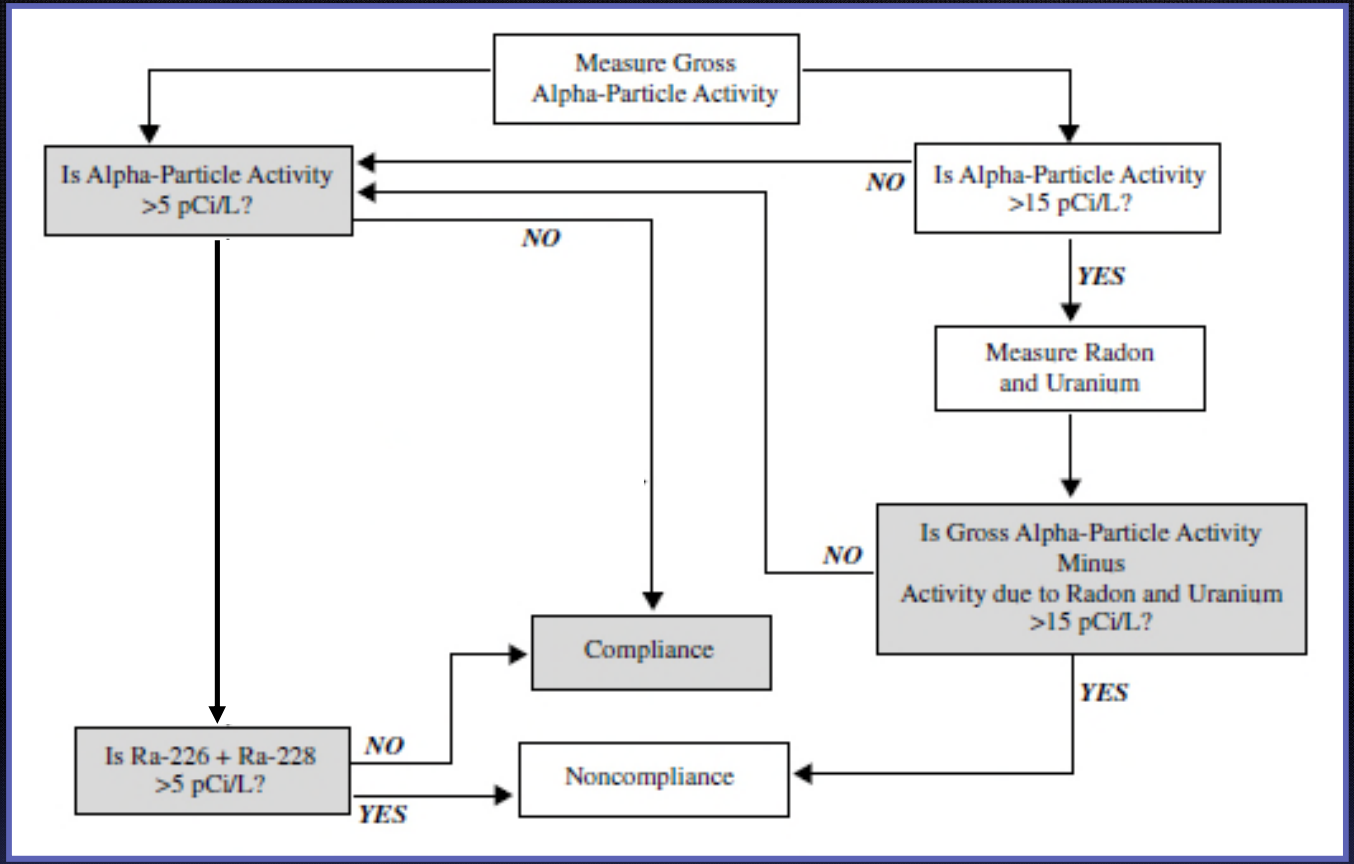


modified from Focazio et. al., USGS WRIR 00-4273

Radium Compliance

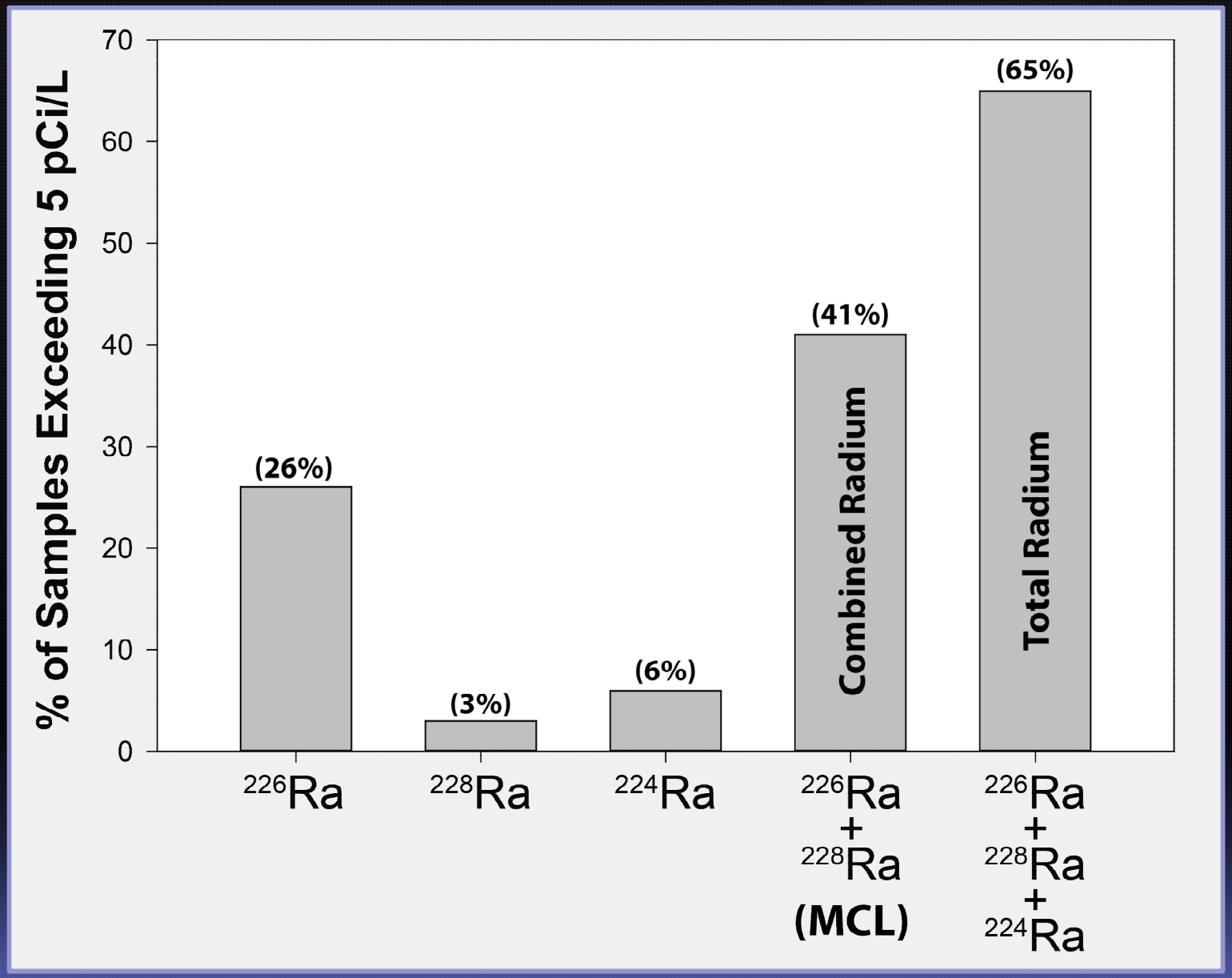
$^{226}Ra + ^{228}Ra$

$MCL = 5.0\ pCi/L$



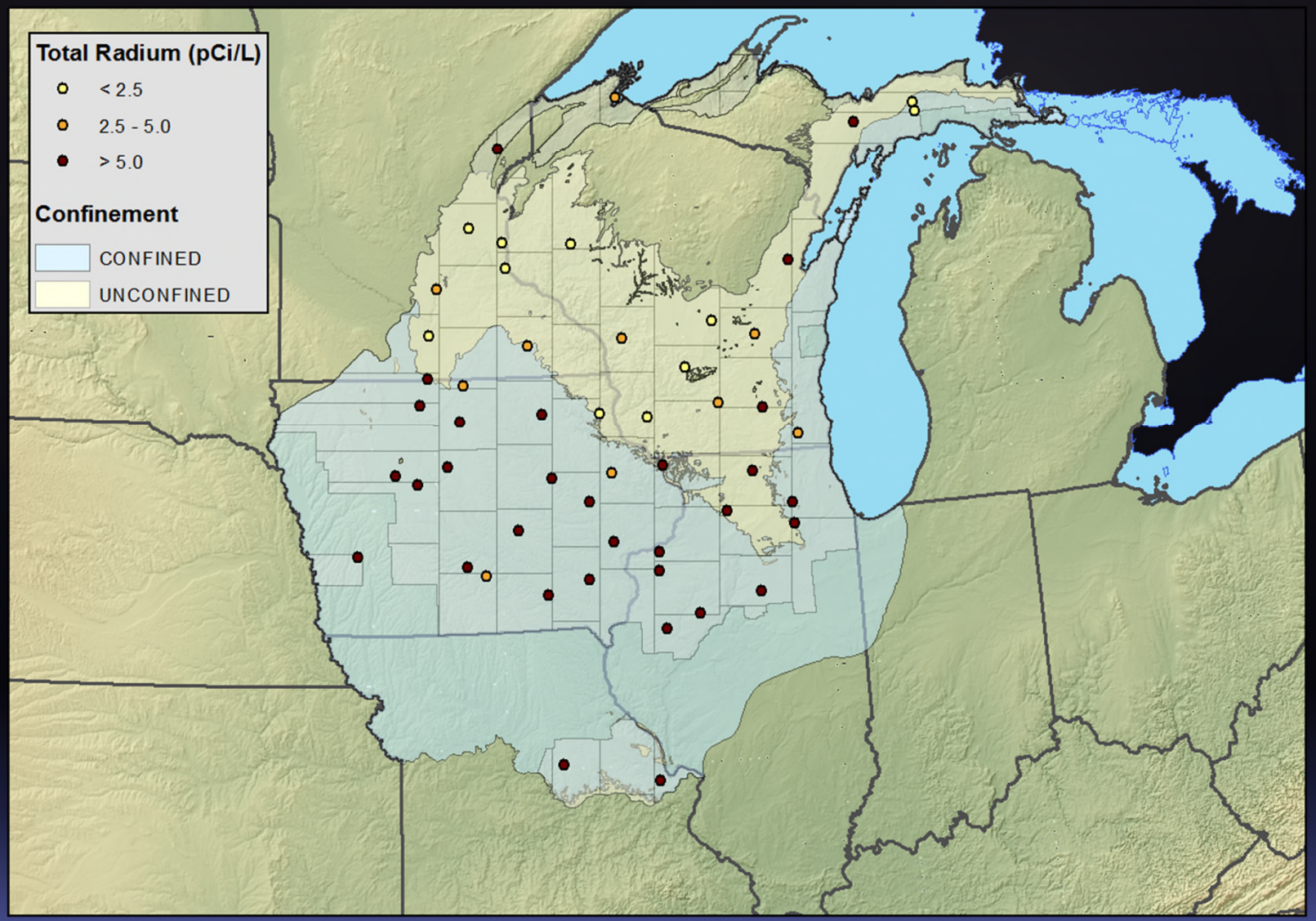
modified from **Focazio and others, USGS WRIR 00-4273**

Percentage of Samples Exceeding the Radium MCL (5 pCi/L)

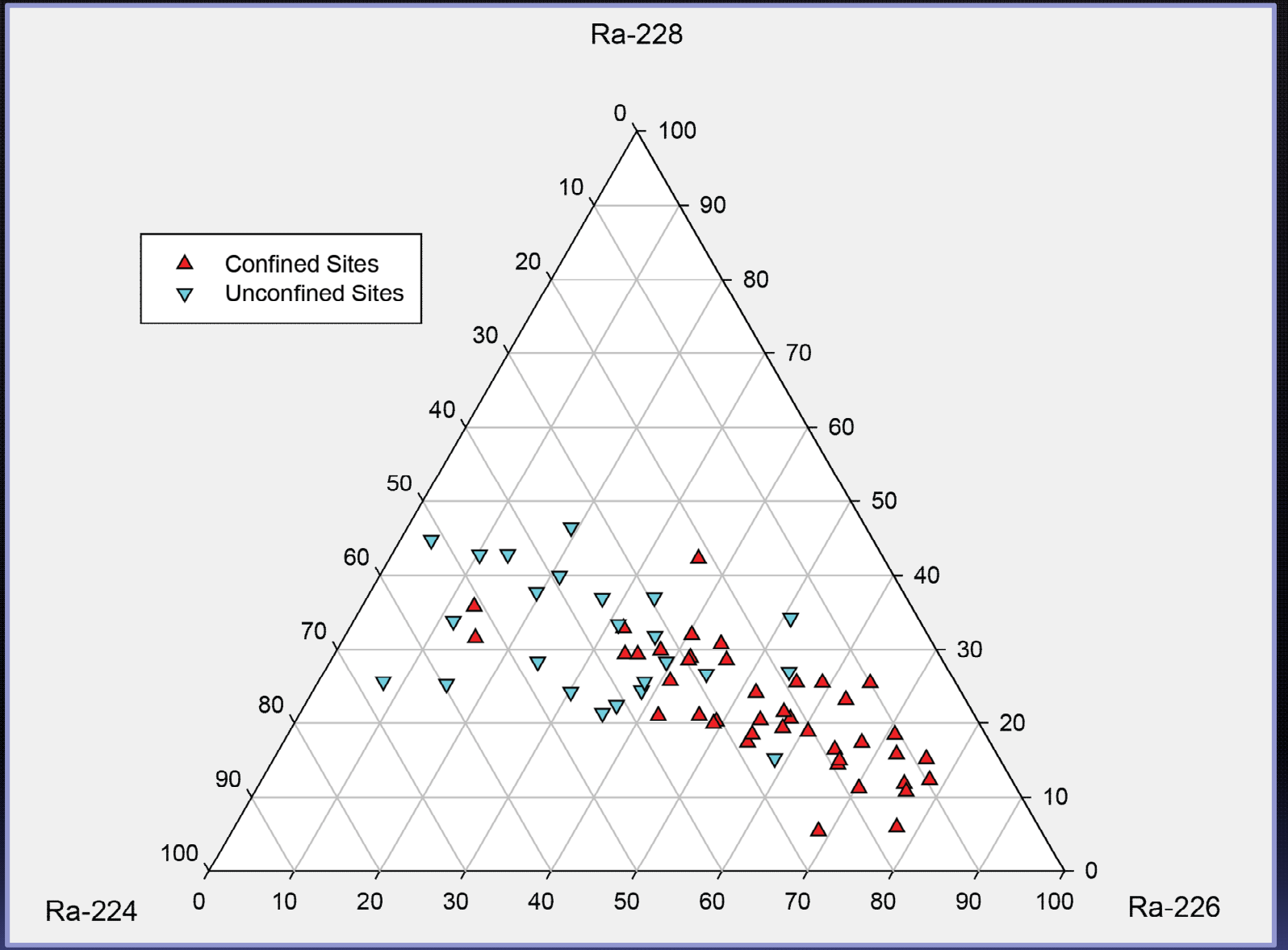


Distribution of Total Radium

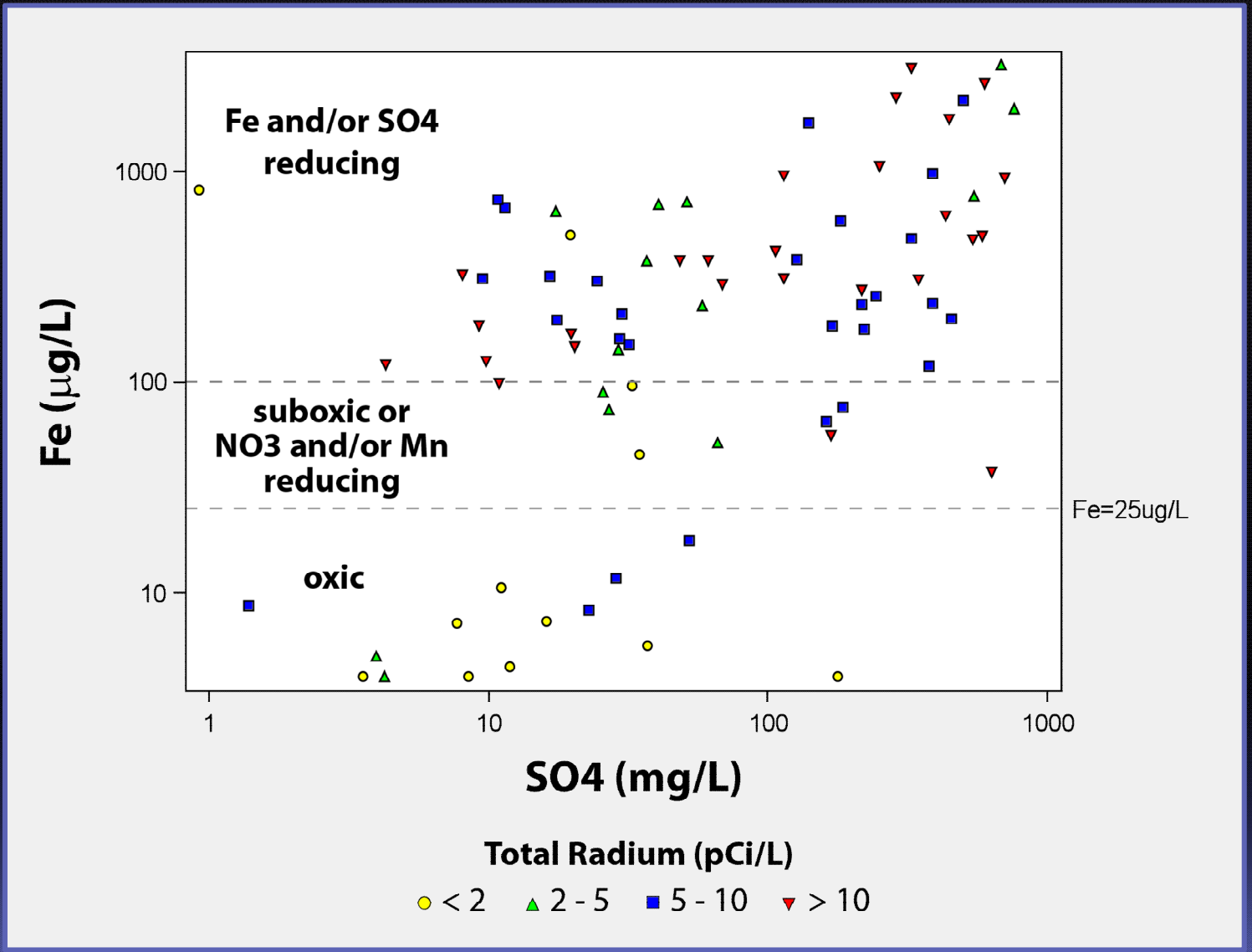
($^{224}Ra + ^{226}Ra + ^{228}Ra$)



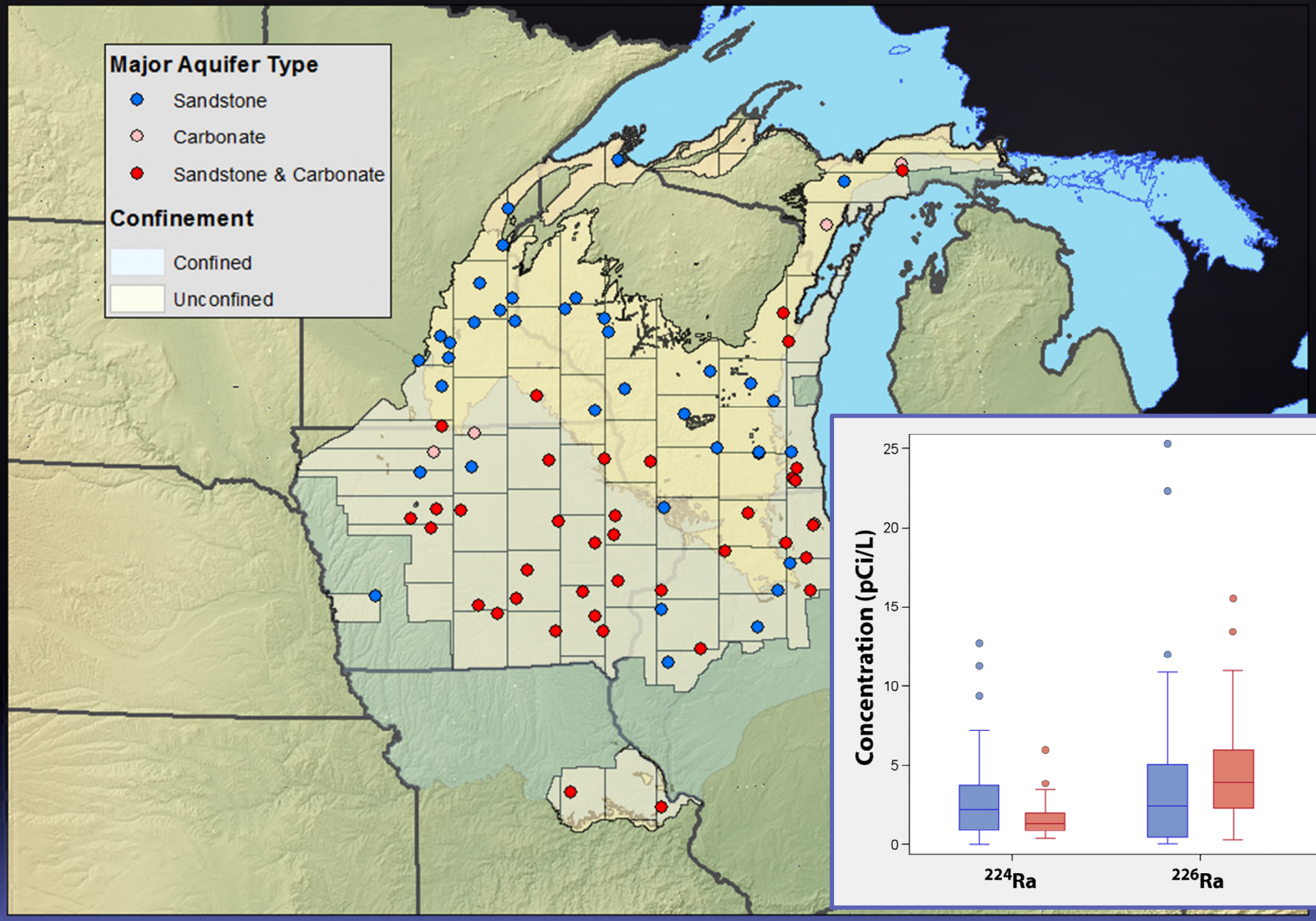
Proportion of Radium Isotopes



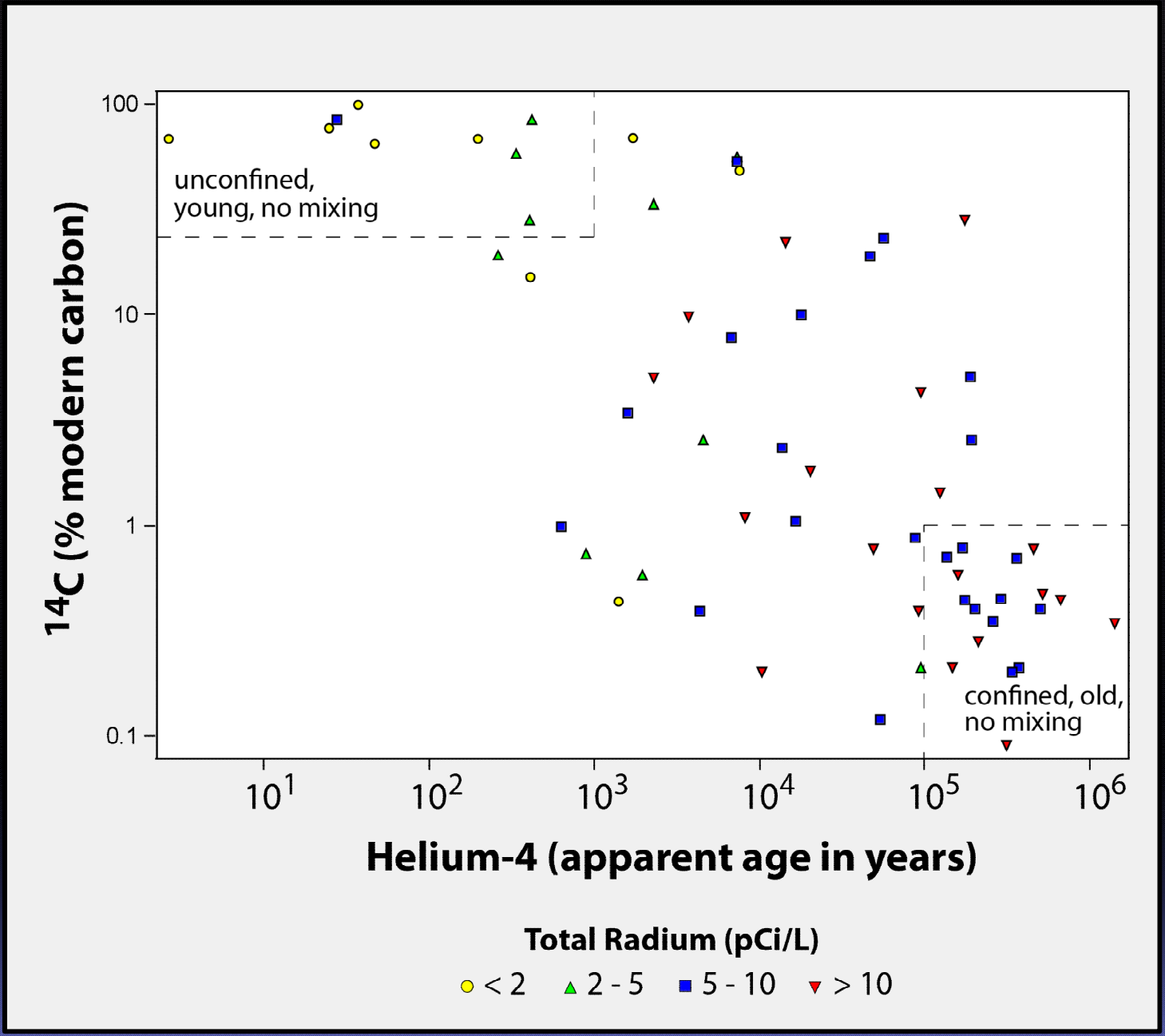
Mineralized & Reducing Conditions Mobilize Radium



Distribution of Radium Isotopes by Aquifer Type

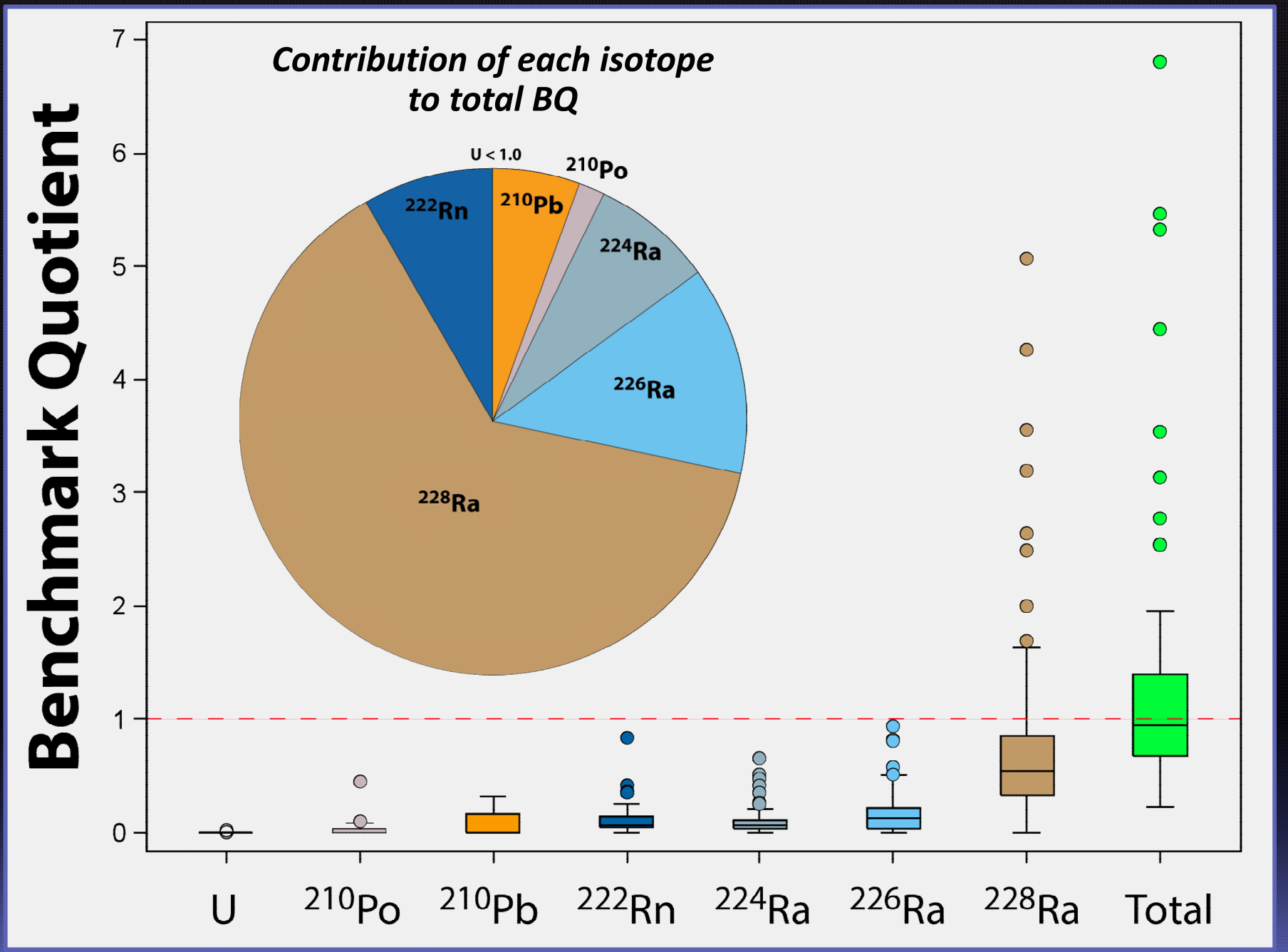


Mineralized & Reducing Conditions Evolve with Residence Time



Human-health Context

Benchmark Quotient = Isotope concentration/WHO guidance value



Summary

- *The Cambrian-Ordovician aquifer system is an important source for public and domestic drinking-water supplies*
- *Age tracers indicate the presence of modern water in the unconfined region and water that is 100's of 1000's of years old in the confined region*
- *41% of samples had a combined radium concentration that exceeded the MCL; 70% in the confined region*
- *65% of samples had a total radium concentration > 5 pCi/L; 83% in the confined region*
- *^{224}Ra has the potential to pose an additional health risk that is not currently accounted for by the MCL*

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Summary – cont.

- *Extended residence time leads to increasingly mineralized and reduced conditions that favor the mobilization of radium isotopes*
- *^{226}Ra becomes enriched relative to ^{228}Ra & ^{224}Ra in the confined region because:*
  - *Increased prevalence of carbonate rocks*
  - *Extended ½-life allows it to remain in solution longer before decaying*
- *^{228}Ra is the only isotope that was measured at concentrations greater than its WHO guidance value*
- *^{228}Ra contributes more than 50% to the total benchmark quotients summed across all samples*

Questions?

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